CLAIMS

1. A method of trapping or guiding ions, comprising:

introducing ions into an ion trap or ion guide, the ion trap or ion guide including a first set of electrodes and a second set of electrodes, the first set of electrodes defining a first portion of an ion channel to trap or guide the introduced ions;

applying periodic voltages to electrodes in the first set of electrodes to generate a first oscillating electric potential that radially confines the ions in the ion channel; and

applying periodic voltages to electrodes in the second set of electrodes to generate a second oscillating electric potential that axially confines the ions in the ion channel.

2. The method of claim 1, wherein:

introducing ions includes introducing positive ions and negative ions into the ion trap or ion guide.

3. The method of claim 2, wherein the ion trap or ion guide includes a first end and a second end, and the positive and negative ions are introduced at the first end and the second end, respectively.

4. The method of claim 2, wherein the ion trap or ion guide includes two or more sections, the method further comprising:

applying one or more DC biases to one or more of the sections of the ion trap or ion guide to confine the positive or the negative ions into one or more sections.

5. The method of claim 1, wherein:

applying periodic voltages to electrodes in the first set of electrodes includes applying periodic voltages with a first frequency; and

applying periodic voltages to electrodes in the second set of electrodes includes applying periodic voltages with a second frequency that is different from the first frequency.

6. The method of claim 5, wherein the first and second frequencies have a ratio that is about an integer number or a ratio of integer numbers.

7. The method of claim 6, wherein the first and second frequencies have a ratio of about two.

8. The method of claim 1, wherein the first and second oscillating electric potentials have different spatial distributions.

9. The method of claim 8, wherein the ion channel has an axis, and the first oscillating electric potential defines substantially zero electric field at the axis of the ion channel, and the second oscillating electric potential defines substantially non-zero electric field at the axis of the ion channel.

10. The method of claim 8, wherein the first oscillating potential includes an oscillating quadrupole, hexapole or larger multipole potential.

11. The method of claim 8, wherein the second oscillating potential includes an oscillating dipole potential.

12. The method of claim 1, wherein:

the first and second oscillating electric potentials define a pseudopotential for each particular mass and charge of the introduced ions such that each of the defined pseudopotentials specifies a corresponding potential barrier along the ion channel.

13. The method of claim 1, wherein:

the first set of electrodes includes a plurality of rod electrodes.

14. The method of claim 1, wherein:

the second set of electrodes includes a plurality of rod electrodes defining a second portion of the ion channel.

15. The method of claim 1, wherein:

the second set of electrodes includes one or more plate ion lens electrodes.

16. The method of claim 15, wherein:

the second set of electrodes includes a first plate ion lens electrode at a first end of the ion channel and a second plate ion lens electrode at a second end of the ion channel.

17. An apparatus, comprising:

a first set and a second set of electrodes, the first set of electrodes arranged to define a first portion of an ion channel to trap or guide ions; and

a controller configured to apply periodic voltages to electrodes in the first set and the second set to establish a first oscillating electric potential and a second oscillating electric potential, wherein the first and second oscillating electric potentials have different spatial distributions and confine ions in the ion channel in radial and axial directions, respectively.

18. The apparatus of claim 17, wherein the controller is configured to confine simultaneously positive and negative ions in the ion channel in both radial and axial directions.

19. The apparatus of claim 17, wherein the controller is configured to:

apply periodic voltages to electrodes in the first set of electrodes with a first frequency; and

apply periodic voltages to electrodes in the second set of electrodes with a second frequency that is different from the first frequency.

20. The apparatus of claim 19, wherein the first and second frequencies have a ratio that is about an integer number or a ratio of integer numbers.

21. The apparatus of claim 17, wherein the first set of electrodes includes a plurality of rod electrodes.

22. The apparatus of claim 17, wherein the second set of electrodes includes a plurality of rod electrodes defining a second portion of the ion channel.

23. The apparatus of claim 17, wherein the second set of electrodes includes one or more plate ion lens electrodes.

24. The apparatus of claim 23, wherein the second set of electrodes includes a first plate ion lens electrode at a first end of the ion channel and a second plate ion lens electrode at a second end of the ion channel.